

## Wastewater reuse in Turkey: from present status to future potential

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### ABSTRACT

The Ministry of Environment and Urbanization (MoEU) initiated an important project, 'Reuse of Treated Wastewater in Turkey', in 2017. With this project, all wastewater treatment plants (WWTPs) were investigated to determine wastewater reuse purposes for the first time. The results obtained from this project were that although there are 1,015 existing WWTPs, only 15 of them realized wastewater reuse. In 2017, the total volume of reused treated wastewater in Turkey amounted to 29.6 million m<sup>3</sup>/year, accounting for 0.78% of the treated urban wastewater. With the present water potential and sectoral water use rates, Turkey should make key administrative and technical regulations in the coming years for water reuse. This paper aims to give an overview of wastewater reuse activities from present status to future potential in Turkey and the opportunities and challenges in expanding water reuse. The status of WWTPs, treatment processes and their compliance with the WWTPs where reuse is carried out in Turkey are evaluated in this study. The realization of the planned goals and challenges are discussed after regulatory changes in Turkey for reclaimed wastewater and reuse targets for 2023.

**Key words** | advanced treatment, reclaimed water, wastewater, wastewater regulations, water reuse

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### INTRODUCTION

The world population is expected to be 9.7 billion and 10.9 billion by the years 2050 and 2100 respectively based on medium-variant projection according to the *World Population Prospects 2019* report published by the United Nations (UN 2019). Both the limited water resources and increase in demand for these resources all over the world in parallel with rapid population growth are considered, and the necessity of reusing water which actually has been applied via different techniques since ancient times

(Angelakis *et al.* 2018) has become unavoidable in today's conditions in order to increase the water supply. The solutions of water reuse remain limited in comparison with their potential. The goal is to encourage using resources efficiently and reduce the pressure on water scarcity by fostering the development of safe reuse (Alcalde-Sanz & Gawlik 2017). Water reuse presents a potential for water management and contributes to reducing fresh water use. On the other hand, contribution to sustainable water management and resource

conservation should be adopted without compromising public health or environmental risk (Al-Jayyousi 2003).

Reuse of water has many advantages such as provision of drinking water especially in countries suffering from water scarcity, improved agricultural production, reduction of energy costs related to production and all other significant environmental benefits (EPA 2012). The two most important factors that should be considered in the application of different purposes in the scope of water reuse are energy efficiency and sustainability (NCSL 2014). In this context, water resources should be planned scrupulously by taking into consideration the water reuse trend for the consumption of both present and future generations. In other words, sustainable water management is required to prevent or solve water-related challenges (WCED 1987). However, most countries are not at the desired level in the field of water reuse. On the other hand, developing countries especially, such as Turkey, are carrying out comprehensive studies on water reuse projects to meet urban demands such as landscape irrigation, agricultural, commercial and industrial needs. The most realistic project that can be implemented within this context is the safe reuse of wastewater at an increasing rate according to the principle of 'fit for purpose' considering both cost and health concerns (NRC 2012).

There is no certain standardization of water reuse criteria throughout the world (Paranychianakis *et al.* 2015). Water quality should be improved for more consistency among different international regulations (Angelakis *et al.* 2018). Paranychianakis *et al.* (2015) conducted a very comprehensive study that reviews the evolution of water reuse criteria and the criteria in EU countries and its comparison among the countries; this study reviewed water reuse and the public health/environmental risk dimension as well. Alcalde-Sanz & Gawlik (2017) prepared a report that scientific support for the development of a legal instrument on minimum quality requirements for water reuse at EU level for irrigation and aquifer recharge should be adopted. There are diverse water reuse realities amongst the countries of the European Union. Whilst in southern Europe wastewater reuse is still a limited, but growing, source of irrigation water, in northern Europe, it is barely practiced but could be developed for sanitation or environmental protection purposes in response to increasingly stringent environmental regulations. In 2006, the total volume of

reused treated wastewater in the EU amounted to 964 million m<sup>3</sup>/year, accounting for 2.4% of the treated urban wastewater (Raso 2013).

Water reuse continues to be a viable option for enhancing water resources in developing countries. One of the ongoing challenges is to convince, not only the communities, but also the political leadership. An array of barriers, including cultural beliefs and investment opportunities continue to influence opportunities for progress negatively (Hyde 2013). A key factor in the successful implementation of wastewater reuse is the public acceptance that can be provided by the high quality of reclaimed water (Asano *et al.* 1996).

Turkey is not a water-rich country in terms of existing water potential. The total, technically and economically usable surface and groundwater potential of Turkey is around 112 billion m<sup>3</sup>, with 96 billion m<sup>3</sup> (86%) coming from rivers located within Turkish borders, 3 billion m<sup>3</sup> (3%) from external rivers originating outside the country's borders and 12 billion m<sup>3</sup> (11%) from groundwater resources. The water resource potential of Turkey is given in Table 1.

Turkey is situated in a semi-arid region and water demand increases with population growth, industrialization,

**Table 1** | Water resource potential of Turkey (State Hydraulic Works 2017)

Source	Value
The average annual rainfall	643 mm/year
Total land area of Turkey	783.577 km <sup>2</sup>
Annual rainfall	501 billion m <sup>3</sup>
Evaporation	274 billion m <sup>3</sup>
Groundwater infiltration	41 billion m <sup>3</sup>
Surface water	
Annual runoff	186 billion m <sup>3</sup>
Available surface water	98 billion m <sup>3</sup>
Groundwater	
Annual amount of potable water	14 billion m <sup>3</sup>
Total available water (net)	112 billion m <sup>3</sup>
Development status	
Used in irrigation	32 billion m <sup>3</sup>
Used in drinking water	7 billion m <sup>3</sup>
Used in industry	5 billion m <sup>3</sup>
Total water consumption	44 billion m <sup>3</sup>

urbanization and rising usage. The utilization rate of 112 billion m<sup>3</sup> of available water resources in Turkey is approximately 39%; 32 billion m<sup>3</sup> of this resource is used for irrigation (73%), 7 billion m<sup>3</sup> (16%) is used for drinking water and urban usage, and 5 billion m<sup>3</sup> (11%) is used in industry. As of 2013, Turkey is among the countries with limited water resources, with 1,500 m<sup>3</sup> of available water per capita. It is expected that Turkey may become one of the countries suffering from water shortage with 1,100 m<sup>3</sup> of available water per capita in the year 2030 (MoD 2013).

The sectoral distribution of water use according to the development levels and industrial water usage in Turkey in comparison with other countries is given in Figure 1. According to the water consumption estimates made on a sectoral basis, all of the 8.5 million hectares area, which is the technically and economically irrigable land resource of the country, is expected to be open to irrigation in 2023 and the consumption of irrigation water to reach 72 billion m<sup>3</sup> (MoD 2013). Thus, it is aimed to reduce the share of the irrigation, which was 73% of total water consumption at the beginning of 2012, to 64% based on the target of 2023. In addition, Turkey used 5 billion m<sup>3</sup>/year for industry in 2012, and it is expected to use 22 billion m<sup>3</sup>/year of water in industry in 2023. Furthermore, it is estimated that the drinking/potable water demand, which was approximately 7 billion m<sup>3</sup> per year in 2012, will reach 18 billion m<sup>3</sup> in 2023. With the present water potential and sectoral water use rates, Turkey should make key

administrative and technical regulations in the coming years in the reuse of treated wastewater area.

The AQUAREC Project (Wintgens & Hochstrat 2006), supported by the European Union (EU), has developed a model to estimate the reuse of treated wastewater in the EU. The current reuse of treated wastewaters in 2000 and potential reuse amounts in 2025 were determined with the model (Raso 2013). According to the model results, it is seen that Turkey can take a place in the ranking for potential reuse at number four after Spain, Italy and Bulgaria in 2025 with 287 million m<sup>3</sup> water reuse per year in the EU. When evaluating this potential, the execution of important projects and research for the reuse of treated wastewater can be foreseen in the coming years in Turkey. Turkey has already launched two important projects after realizing this potential in the reuse of wastewater.

This paper aims to give an overview of wastewater reuse activities from present status to future potential in Turkey and also the opportunities and challenges in expanding water reuse. The current status of wastewater treatment plants (WWTPs), the distribution of various treatment processes, and the compliance of treatment processes with the WWTPs where reuse is carried out in Turkey are evaluated in this study. In addition, the current regulation in Turkey and recent developments in the planned regulation changes are also presented in this study. The realization of the planned goals and challenges are discussed after regulatory changes for reclaimed wastewater and reuse targets in Turkey for 2023.

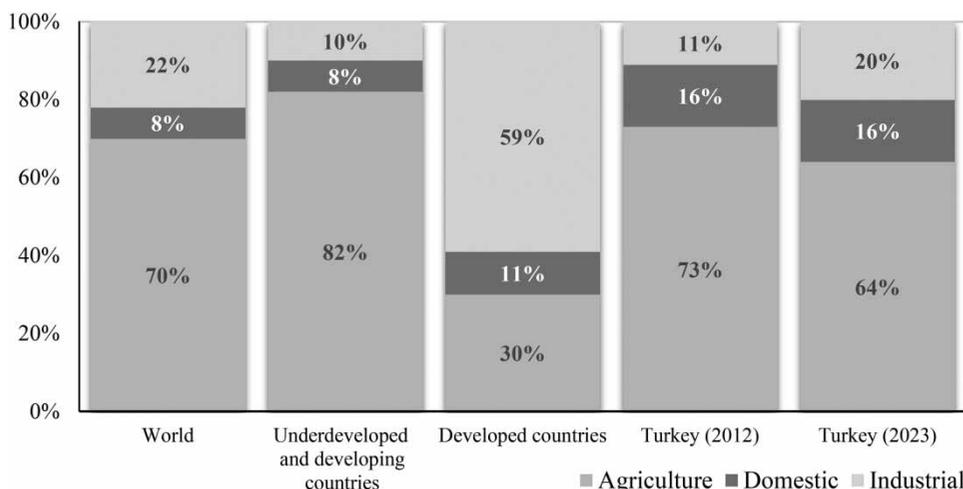


Figure 1 | Sectoral water uses and distribution according to the country levels and Turkey's position.

## WASTEWATER TREATMENT AND WATER REUSE STATUS OF TURKEY

The Ministry of Environment and Urbanization (MoEU) carried out a major project in 2016 to determine the status of wastewater treatment in Turkey including the efficiency and operational problems of domestic wastewater treatment plants in the whole country. Within the scope of the ‘Determination of the Current Status of Domestic/Urban Wastewater Treatment Plants and Determining the Need for Revision (TURAAT)’ project, it has been determined that Turkey has 1,015 domestic wastewater treatment plants either in operation or under construction and 10.5 million m<sup>3</sup> wastewater is treated daily (MoEU & SU 2016). According to the TURAAT project, the proportion of treated wastewater is found to be 82.9% generated by municipalities. In 2018, this rate had increased to 85%. Turkey’s final target rate of municipality wastewater treatment is 100% in the year 2023. Figure 2 shows both distributions of WWTPs and the amount of wastewater treated in them throughout the country.

In 2017, the MoEU initiated the second important project, ‘Reuse of Treated Wastewater in Turkey’. Within the

scope of this project, it is aimed to investigate national and international practices and standards for the reuse of wastewater for urban and industrial wastewaters and to propose technical and administrative criteria for establishing the legal framework for the reuse of treated wastewater specific to Turkey. With this project, all WWTPs were investigated to determine wastewater reclamation and reuse purposes for the first time (MoEU & SU 2018).

According to the results obtained from this project, although there are 26 WWTPs with different capacities of reuse facility, only 15 of them realized reuse in 2017. The remaining 11 WWTPs do not operate their wastewater reclamation facilities due to design, mechanical and operational problems of the tertiary treatment processes. The amount of water reclaimed and reused from domestic/urban WWTPs was determined to be 29.6 million m<sup>3</sup>. According to the results obtained, the reuse rate of domestic wastewater in Turkey was calculated as 0.78%. In 2016, the city of Kocaeli has an important share in Turkey with a ratio of 57.8% according to the reclaimed wastewater rates at WWTPs. Kocaeli is followed by İstanbul with a rate of 19.2% (Figure 3). In Turkey, industrial reuse of treated domestic wastewater has first place with a 56.8% ratio, followed

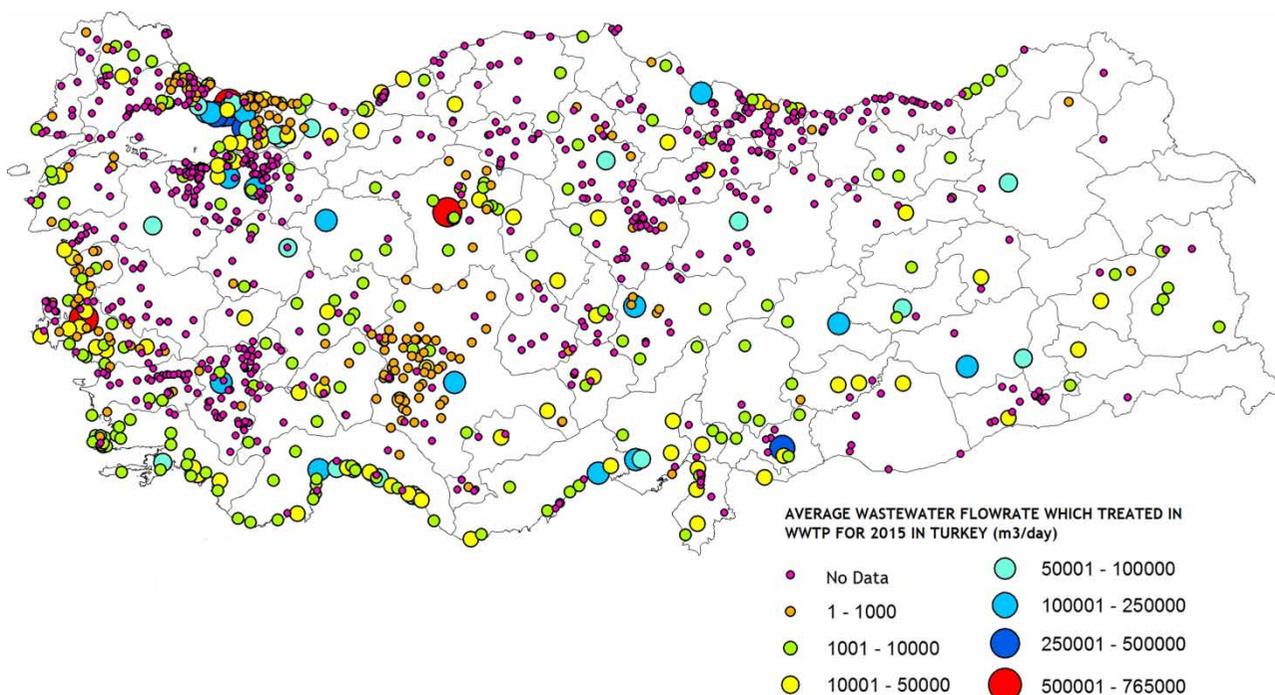
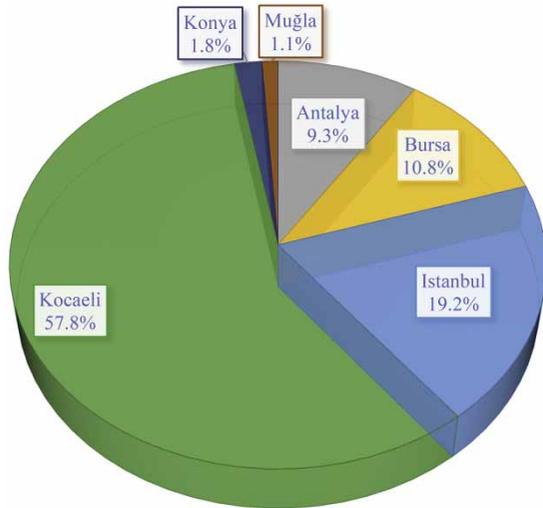
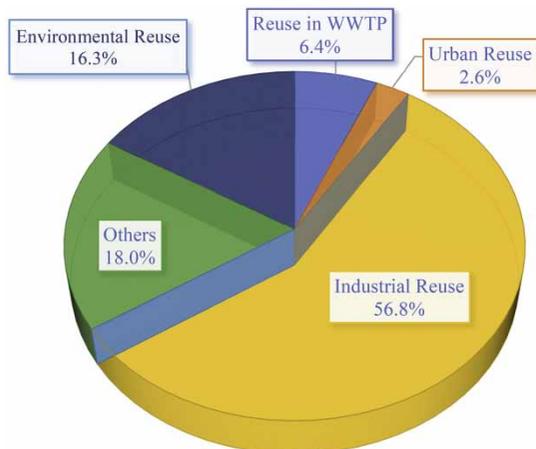


Figure 2 | Amount of wastewater treated in domestic/urban WWTPs throughout the country (MoEU & SU 2016).



**Figure 3** | The major cities that realize wastewater reclamation and reuse in Turkey.

by 16.3% environmental/ecological reuse, in-plant reuse with 6.4% (green area irrigation, processes, washing etc.) and urban reuse (green area irrigation) with 2.6% (Figure 4). Reuse applications in water deficit industrial regions is the highest in Turkey due to water shortages and high water-consumption rates compared with other areas. Reuse of treated wastewater from the domestic WWTPs for planned agricultural irrigation purposes is not currently available. Wastewater reuse applications in the field of agriculture are carried out as 'de facto re-use' by withdrawing river water downstream or lake water from discharged effluent of WWTPs.



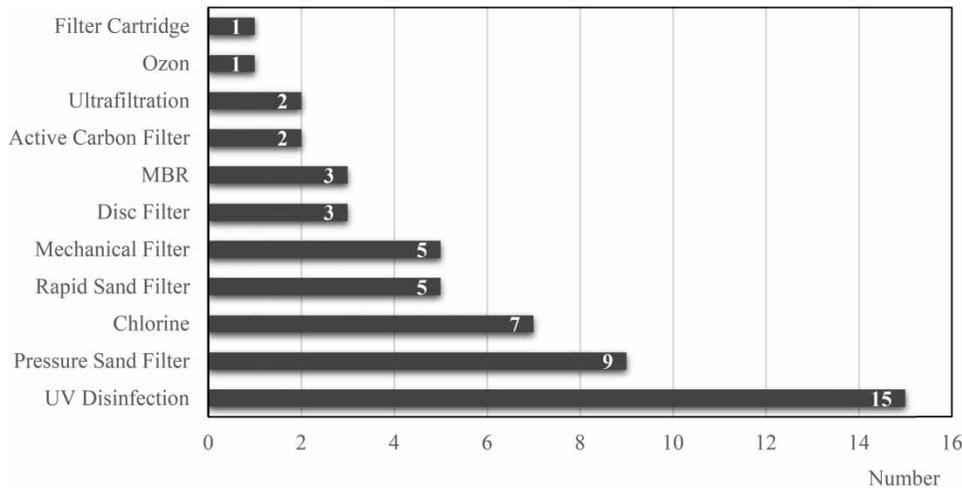
**Figure 4** | Nationwide reuse purposes of reclaimed water in Turkey.

Figure 5 shows the distribution of tertiary treatment processes in 26 WWTPs built for different wastewater reclamation purposes in Turkey. When the tertiary treatment processes in the country are considered, it is found that there are 15 UV disinfection, nine pressure sand filter, seven chlorination, five rapid sand filter, five mechanical filter, three disc filter, three membrane bioreactor (MBR), two activated carbon, two ultrafiltration, one ozone disinfection, one multimedia sand filter and one cartridge filter.

The following processes for the purpose of reuse in WWTPs are common in Turkey:

- Pressurized multimedia sand filter + UV disinfection
- Pressurized multimedia sand filter + Chlorine disinfection
- Pre-chlorination + Pressurized multimedia sand filter + UV disinfection + Final chlorination
- Pressurized multimedia sand filter + Activated carbon + UV disinfection
- Pressurized multimedia sand filter + Ultrafiltration + Chlorine disinfection
- Rapid sand filter + UV disinfection
- Rapid sand filter + Chlorine disinfection
- Mechanical filter + UV disinfection
- Mechanical filter + Ultrafiltration
- Disc filter + UV disinfection
- Pre-chlorination + Pressurized multimedia sand filter + UV disinfection + Ozonation + Final chlorination
- MBR + UV disinfection

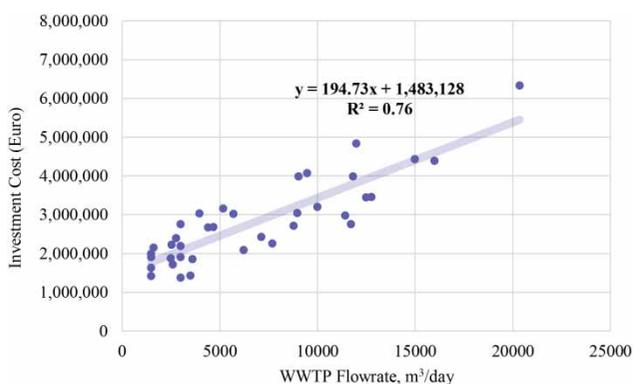
Figure 5 shows the distribution of existing tertiary treatment processes for reuse of wastewater in Turkey including the usage of filtration processes such as pressurized multimedia sand filter, rapid sand filter, mechanical filter, and disc filter to remove TSS and turbidity after secondary treatment effluent and followed by disinfection processes of either UV or chlorine disinfection. Some of the mentioned plants perform UV disinfection, ozonation and final chlorination together as a multi-barrier application. In addition, three MBR processes end with a UV disinfection unit. Considering tertiary treatment processes aiming at wastewater reclamation, it is determined that there are some operational problems mostly related with the design bed speed of pressurized multimedia sand filters. In addition, rapid sand filters are found to be more efficient in terms of operational



**Figure 5** | The distribution of the constructed tertiary treatment processes across the country.

problems compared with pressurized multimedia sand filters. It is also found that application of disc filters produced in Turkey as a tertiary treatment process in three WWTPs could not be operated due to mechanical problems. There are some operational problems faced in 15 WWTPs which applied UV disinfection. The main problem here is the inefficiency of filtration systems prior to UV disinfection. In addition to this, breakage of UV lamps and high operating costs are the other problems that are faced frequently.

Initial investment costs of 37 constructed WWTPs having a biological process including phosphorus removal and a simultaneous nitrification denitrification (SNdN) process and with flow rates ranging between 2,000 and 20,000 m<sup>3</sup>/day are given in Figure 6. In addition, initial



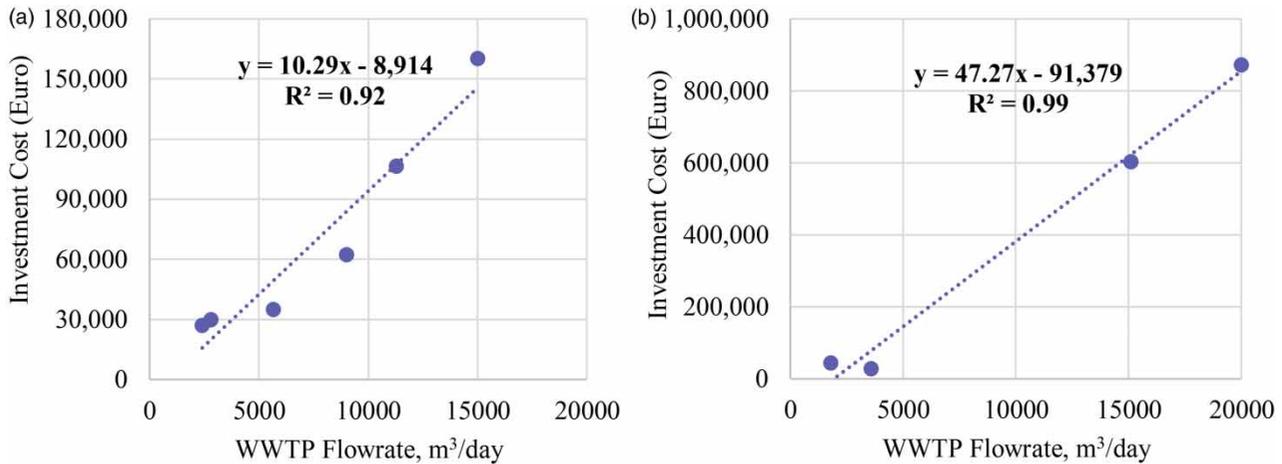
**Figure 6** | Investment cost of WWTPs having simultaneous N/D process with phosphorus removal constructed in Turkey.

investment costs of UV disinfection processes and pressurized multimedia sand filters constructed for the aim of wastewater reclamation for the same flow rates are shown in Figure 7. When these figures are evaluated together, if wastewater reclamation is targeted for the SNdN process with phosphorus removal, the calculated cost rates of the sand filter and UV disinfection processes used prevalently in Turkey are as given in Table 2. The percentage of the UV disinfection process in the total investment cost is calculated as 1.7% for a WWTP having 5,000 m<sup>3</sup>/day capacity, and this ratio is 5.6% for the sand filter.

Six different WWTPs which are selected due to their best application practices in the field of water reuse are given in Table 3. These wastewater reclamation facilities have various tertiary treatment processes and their purpose of reuse varies, such as urban reuse, environmental reuse and industrial reuse. Operating costs for the plants with sand filter and UV are dramatically lower compared with the plants with MBR.

Examples of successful applications of the reuse of treated domestic wastewater throughout the country include the following.

The Purple Pipe Network application project at Konya WWTP has been in operation since 2013 with a new distribution network of 24 km for urban green area irrigation. Kocaeli Körfez WWTP, Kullar WWTP and Kocaeli Plajyolu WWTP are good examples of successful applications of industrial reuse. Istanbul Paşaköy WWTP with a 75,000 m<sup>3</sup>/day



**Figure 7** | Additional investment cost of processes constructed after secondary treatment of WWTPs for wastewater reclamation: (a) UV processes, (b) pressurized multimedia sand filters.

flow rate supplies reclaimed water for various purposes. Antalya Hurma WWTP produces cooling water from reclaimed wastewater. Konacık WWTP in Muğla sells the reclaimed wastewater to be used in irrigation for the urban green area according to the protocol made with Bodrum Municipality. In addition to this protocol, the reclaimed wastewater is sold to 120 residential subscribers as irrigation water.

## NEW REGULATION PROPOSAL FOR REUSE IN TURKEY

Turkey has begun to apply wastewater reuse with the 'Notification for Wastewater Treatment Plant Technical Procedures' (Official Gazette 2010). In the seventh chapter of the notification, prepared by the Ministry of Environment and Forestry, which entered into force on March 20, 2010, there are regulations regarding the reclamation and reuse of wastewater. According to the notification, the requirements of the treated wastewater to be reused in irrigation, the chemical quality criteria for irrigation water, and the

concentrations of the maximum heavy metal and toxic elements permissible in irrigation waters were determined for the first time. The criteria aforementioned in the notification were taken from the guidelines for water reuse of the US Environmental Protection Agency (US EPA) *Guidelines for Water Reuse* (EPA 2004).

With the aim of updating the regulation applied since 2010, the 'Reuse of Treated Wastewater' project has been carried out in Turkey. The methodology given below has been implemented during the preparation of the proposed regulation for the reuse of treated wastewater:

- examination of current national regulation,
- evaluation of the current wastewater treatment technologies, treatment efficiencies and water reuse experiences in Turkey,
- evaluation of international experiences,
- evaluation of developments in treatment technologies,
- evaluation of the effects of pollutants in the reclaimed wastewater regarding the environment and public health,
- evaluation of regulation practices in the world (USA, EU, Singapore, Australia, Spain, Italy, France, Israel etc.),
- detailed evaluation of the regulation arrangements of all states in the USA from the 2012 *Guidelines for Water Reuse*,
- determination of technical criteria for regulations specific to Turkey.

Alternative treatment technologies, water quality criteria and monitoring frequencies have been proposed for

**Table 2** | Cost share of sand filters and UV disinfection in total cost for WWTPs for wastewater reclamation

Flow rate (m <sup>3</sup> /day)	Rapid sand filter (%)	UV (%)
5,000	5.6	1.7
10,000	10.0	2.7
20,000	13.7	3.5

**Table 3** | Selected water reclamation and reuse plants operated in Turkey

City	Plant	Reclaimed flow rate (m <sup>3</sup> /day)	Process	Operating cost <sup>a</sup> (euro/m <sup>3</sup> )	Reuse area
Antalya	Gazipaşa WWTP	4,400	MBR	0.22	<ul style="list-style-type: none"> <li>• Environmental (Hacımusla stream, river flow)</li> </ul>
Konya	Konya WWTP	3,600	Pre-chlorination + Pressurized sand filter + UV disinfection + Final chlorination	0.05	<ul style="list-style-type: none"> <li>• Urban reuse (purple pipes network)</li> </ul>
Antalya	Hurma WWTP	3,120	UV + Cartridge filter	–	<ul style="list-style-type: none"> <li>• In-plant green area irrigation</li> </ul>
			Coarse filter + Mechanical filter	0.03	<ul style="list-style-type: none"> <li>• In-plant thermal drying unit, cooling water</li> </ul>
Kocaeli	Körfez WWTP	44,000	Rapid sand filter + Pressured sand filter	0.01	<ul style="list-style-type: none"> <li>• Reuse in industry</li> </ul>
Kocaeli	Plajyolu WWTP	10,000	Rapid sand filter + UV	0.01	<ul style="list-style-type: none"> <li>• Reuse in industry</li> </ul>
İstanbul	Paşaköy	75,000	Rapid sand filter + UV	0.01	<ul style="list-style-type: none"> <li>• In-plant reuse</li> <li>• Transfer to Tuzla AAT for in-plant reuse</li> <li>• Environmental (Riva stream, river flow)</li> </ul>

<sup>a</sup>Electricity and chemical expenses are included while maintenance, repair and personnel expenses are excluded.

each of the different reuse categories (urban, agricultural, environmental, industrial, aquifer feeding). With the proposed regulation, environmental reuse, industrial reuse, and aquifer feeding have been discussed for the first time in addition to the urban reuse and agricultural reuse already included in the regulation introduced in 2010. Following Paranychianakis *et al.* (2015) and Angelakis *et al.* (2018), two matters were borne in mind, namely water quality criteria and monitoring frequencies, while determining wastewater reclamation treatment alternatives. The water scarcity projections and the increase in the agricultural and industrial demands made Turkey set an ambitious target for water reuse. Turkey's 2023 target of water reuse is 5% while providing protection for environmental and public health. The criteria and values proposed for various water reuse purposes by the project are still in the evaluation phase of the MoEU.

## CONCLUSIONS

Turkey is in a position of suffering from water shortage with total amounts of 112 billion m<sup>3</sup> of available water and 1,500 m<sup>3</sup> of water per capita. Water demand in Turkey is increasing due to population growth and industrialization.

The demand for irrigation and industrial water is expected to increase significantly. According to the sectoral water consumption estimates, an 8.5 million hectares area of technically and economically irrigable land resource of the country is expected to be opened to irrigation in the year 2023. In parallel with this target, the water allocation share of irrigation is expected to reach 72 billion m<sup>3</sup>. In addition, drinking/potable water demand is estimated to reach 18 billion m<sup>3</sup> in 2023, having been 7 billion m<sup>3</sup> per year in 2012.

As a result of increasing demand, drought and pollution in catchment areas, the amount of water presently available in Turkey is becoming unable to meet needs. The main problems encountered in water resources management are inadequacy of planning, monitoring, evaluation and control and poor coordination between organizations.

The MoEU, engaged in planning WWTPs with the approach that WWTPs are a source of raw materials, energy and water recovery, has set the target for 2023 of 5% reuse by different purposes such as agricultural irrigation, ground-water supply, irrigation for urban purposes, irrigation for wetlands and rivers, environmental/ecological use as well as for prevention of salt water incursion into fresh groundwater due to excessive groundwater use at the seaside in Turkey. However, there are some obstacles to achieving this 5% target. These possible obstacles can be listed as follows.

### Technical barriers

The main driver and barrier of wastewater reuse in many regions of the world is the insufficiency of efficient collection and treatment systems for wastewater. According to the TURAAT project conducted in 2016, the wastewater treatment rate was 82.9% in Turkey. The current rate of reuse is 0.78% due to the lack of tertiary treatment aiming at wastewater reclamation in existing WWTPs.

### Social perception/educational barriers

The reuse of wastewater for agricultural irrigation, which is the most important area for reuse, and the perceptions of the public, which encourage a preference for the use of fresh water, are both socio-cultural habits, being afraid of the dangers of consuming food irrigated by wastewater.

### Economic barriers

Reclaimed wastewater should be more affordable than fresh water in order to make reclaimed wastewater more attractive to potential users, at least for early adopters. An important challenge for the reuse of wastewater is that the payback period of reuse projects in the short-term is high and it is only feasible in the long-term.

### Corporate and organizational barriers

The responsibility of different institutions in water management and the fragmentation of authority is another obstacle that needs to be overcome in order to progress in reuse projects.

The following issues were noticed when examining the current status of water reclamation and reuse in Turkey:

1. Failure to understand the legal regulations given in the 'Notification on Wastewater Treatment Plants Technical Procedures'.
2. The legal criteria given in the Notification are not very suitable for Turkey, having been created directly from the guidelines given in EPA (2004).
3. Failure to adopt a 'fit for purpose' approach to the treatment.

4. Priorities of WWTPs are for solely meeting discharge standards, and reclamation and reuse are not considered.
5. Design of WWTPs with reuse processes without customer analysis or needs.
6. No cost-benefit analysis for each reuse facility.
7. Unpredictable water quality with existing technologies.
8. Irregular operation and frequent failure of UV disinfection systems due to occasional operational problems in WWTPs.
9. Lack of qualified personnel.

Suggestions for improving the water reuse rate in Turkey can be listed as follows:

1. The uncontrolled and free use of groundwater, which is a strategic resource, for industrial and agricultural purposes should be legally prohibited.
2. Incentive policies for industries reusing the reclaimed wastewater should be promoted.
3. In order to promote the use of treated domestic/urban wastewater for agricultural irrigation purposes, additional support and incentives should be given to the farmers who produce by using wastewater in irrigation in the Agricultural Support Program by the Ministry of Food, Agriculture and Livestock. In addition, in order to eliminate the existing negative public perception, the pilot projects should be carried out in the Research Institutes of the Ministry of Food, Agriculture and Livestock and the results of these studies should be disseminated.
4. Policies should be developed to reduce initial investment costs by encouraging the domestic production of filtration, disinfection and membrane processes.
5. In order to discharge wastewater to drinking water sources/groundwater and to reuse from these sources, it is necessary to adopt a new regulation in the national regulation and to facilitate limit values and permits to ensure that the reuse is healthy, sustainable and widespread.
6. Water use in industry will increase in line with the targets for Turkey in 2023. In addition to the reuse of reclaimed wastewater in industry, studies and arrangements should be made in order to increase the reuse of industrial effluents after the production process.

7. Training/workshop activities about water reuse should be carried out at a national scale.

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